Silvicultural and Ecological Considerations Of Forest Biomass Harvesting in Massachusetts

Massachusetts Sustainable Forest Bioenergy Initiative

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Silvicultural question:

1. **What is the potential quantity of biomass fuel that could be harvested from a typical sawtimber stand in Massachusetts?**

Methods:

- **Used 1998-2000 data from state CFI plots (for public lands) and USFS FIA plots (for private lands)**
- **Used USFS tree biomass equations to calculate total stand biomass**
- **Modeled crown thinning (50% biomass removal)**

Biomass of typical sawtimber stand in Massachusetts (age 70-100 years)

	dry tons/acre
Total tree biomass	70
Large high-quality trees	25
Large cull trees	22
Small trees	15
Harvest residues (slash)	9
Potential biomass harvest	45

Typical partial harvest (patch selection) in Massachusetts

Typical partial harvest in sawtimber stand in Massachusetts (age 70-100 years)

	dry tons/acre	MBF/acre
Large high-quality trees		3
Large cull trees	7	
Small trees	15	
Harvest residues (slash)	3	
Total biomass harvest	25	

Silvicultural question:

2. At statewide level, what is the total annual sustainable biomass harvest (based on the total annual forest growth)?

Methods:

- **Determined area of public and private forestland in state**
- **Reduced public land area based on reserves, and reduced private land based on landowner willingness to harvest**
- **Determined mean forest growth rate using growth model FVS-NE (also known as NE-TWIGS)**

Statewide land area and harvest level

Mean biomass growth rate	**0.9 dry tons/acre/year**
Land available for harvest	
public land	**465,000 acres**
private land $\geq$ 10 acres	**1,070,000 acres**
private land $\geq$ 100 acres	**380,000 acres**
Sustainable harvest level	
public + private $\geq$ 10 acres	**890,000 dry tons/year**
public + private $\geq$ 100acres	**500,000 dry tons/year**

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***Demand for biomass from forestry:* 526,000 dry tons/year**

This “sustainable harvest level” is based on the traditional “sustained yield” calculations based on forest growth rates remaining constant

It is necessary to examine ecological sustainability of those forest growth rates

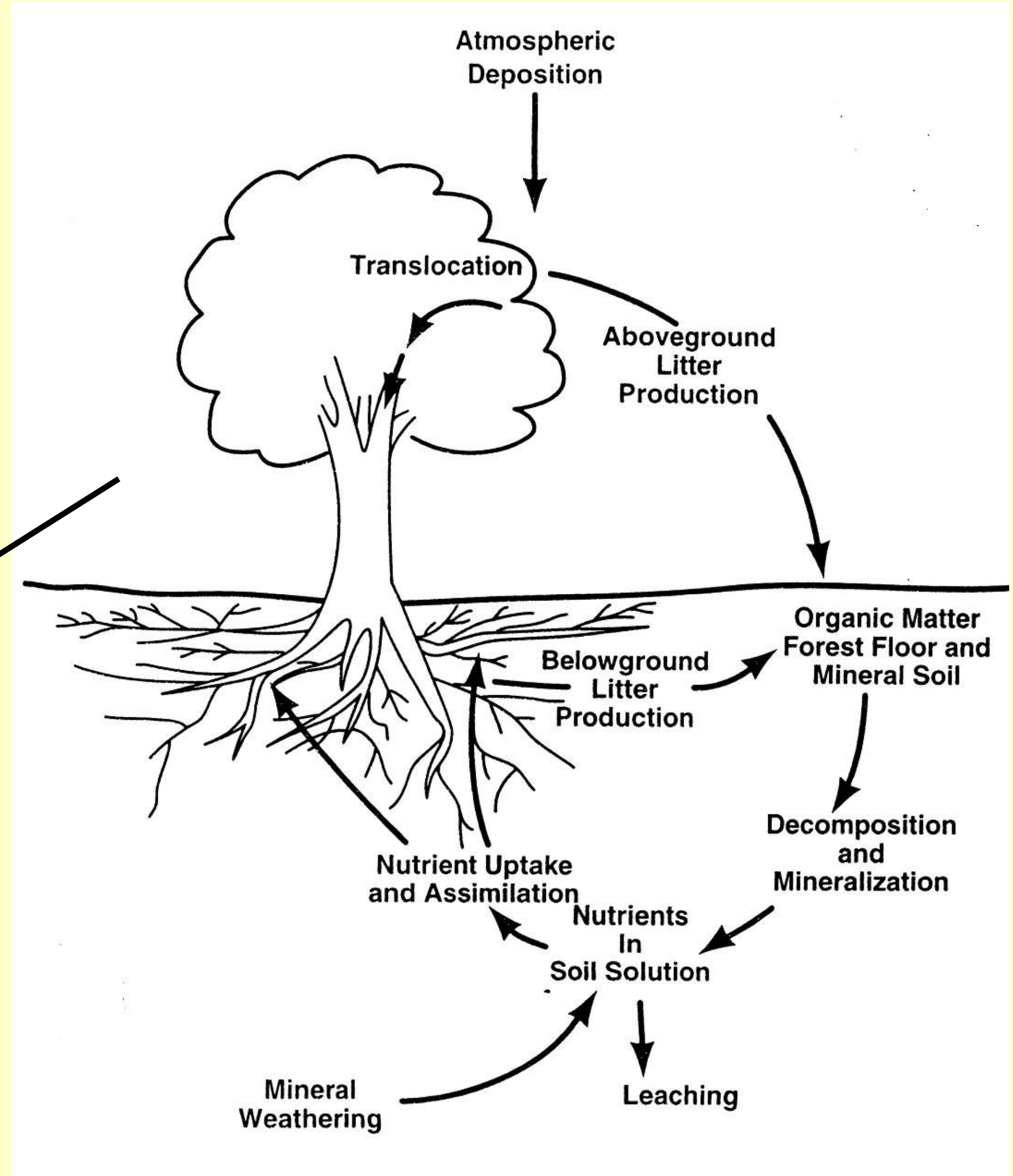
Ecological implications of increased harvesting intensity for biomass

- Nutrient cycling and retention
- Streamflow and water quality
- Wildlife habitat conditions
- Maintenance of high carbon sequestration rate

Nutrient cycling and retention

- Nitrogen, phosphorous, potassium, magnesium, calcium are important nutrients in forests
- Sugar maple growth has been reduced by loss of K, Mg, Ca
- Calcium has become the critical nutrient in the Northeast US

Nutrient inputs, outputs, and cycling

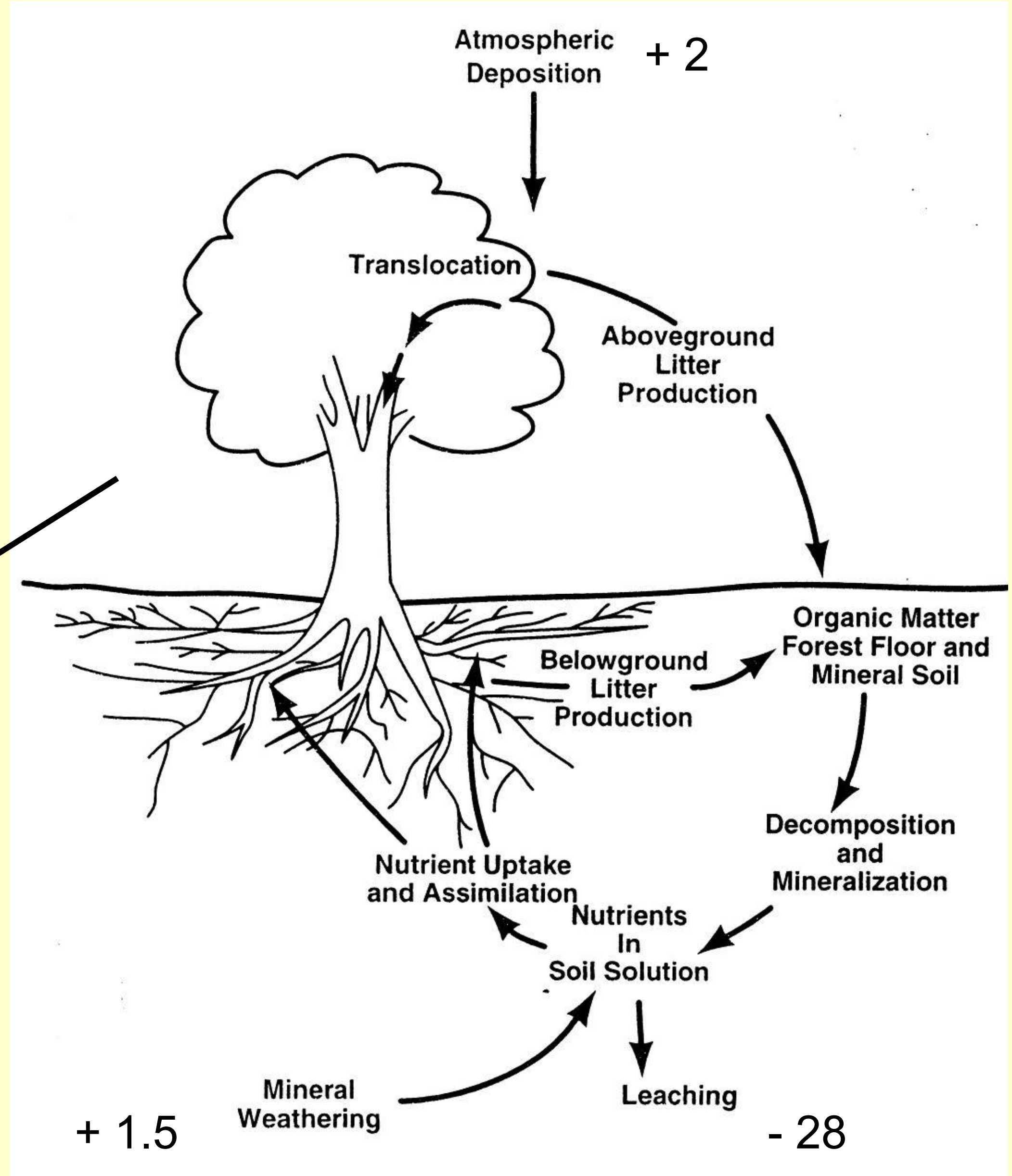


harvest

Calcium loss from clearcut and thinning harvests

(units are kg/ha)

Clearcut harvest
removal
- 530

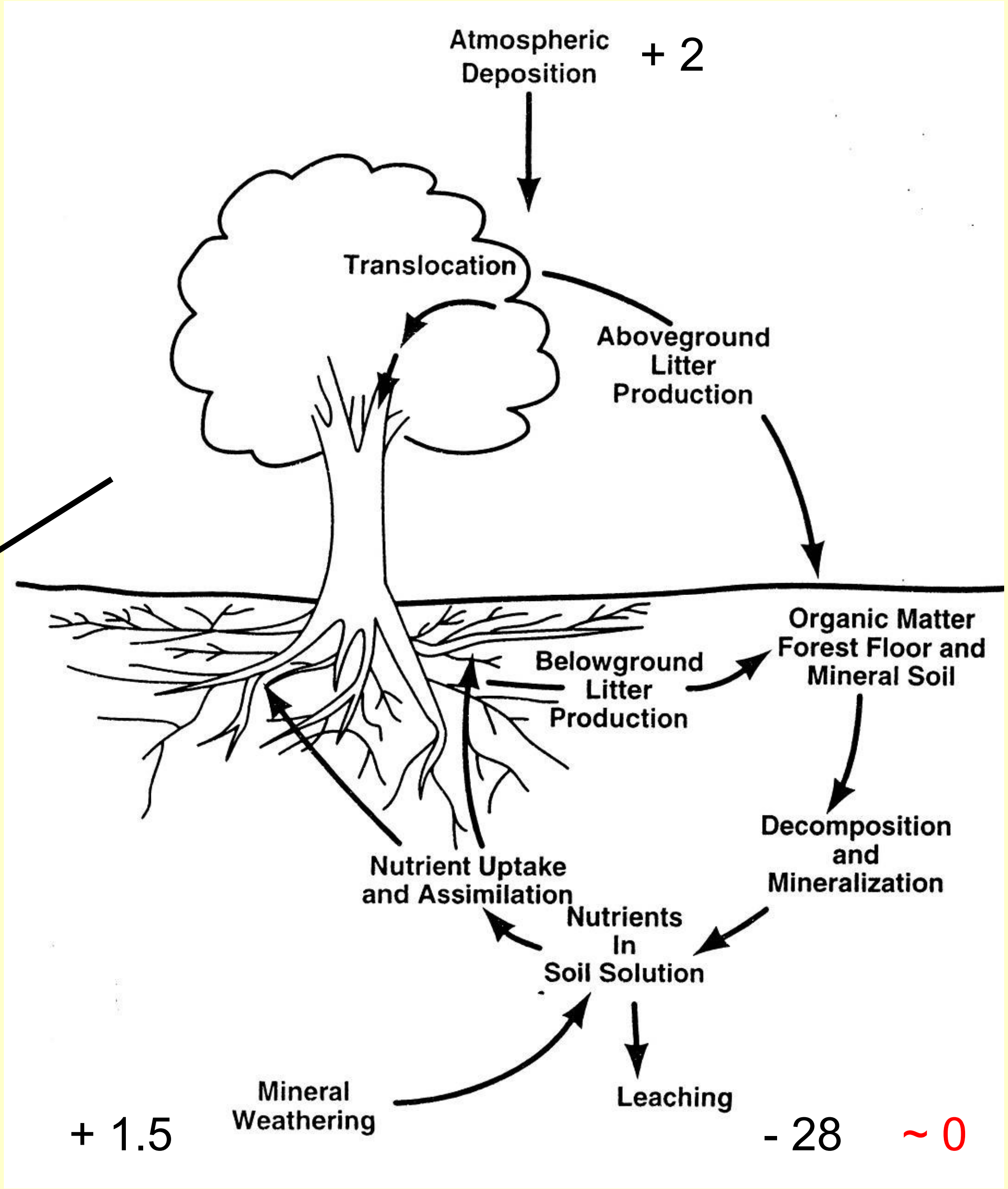


Calcium loss from clearcut and thinning harvests

(units are kg/ha)

Clearcut harvest removal
- 530

Thinning harvest removal
- 250

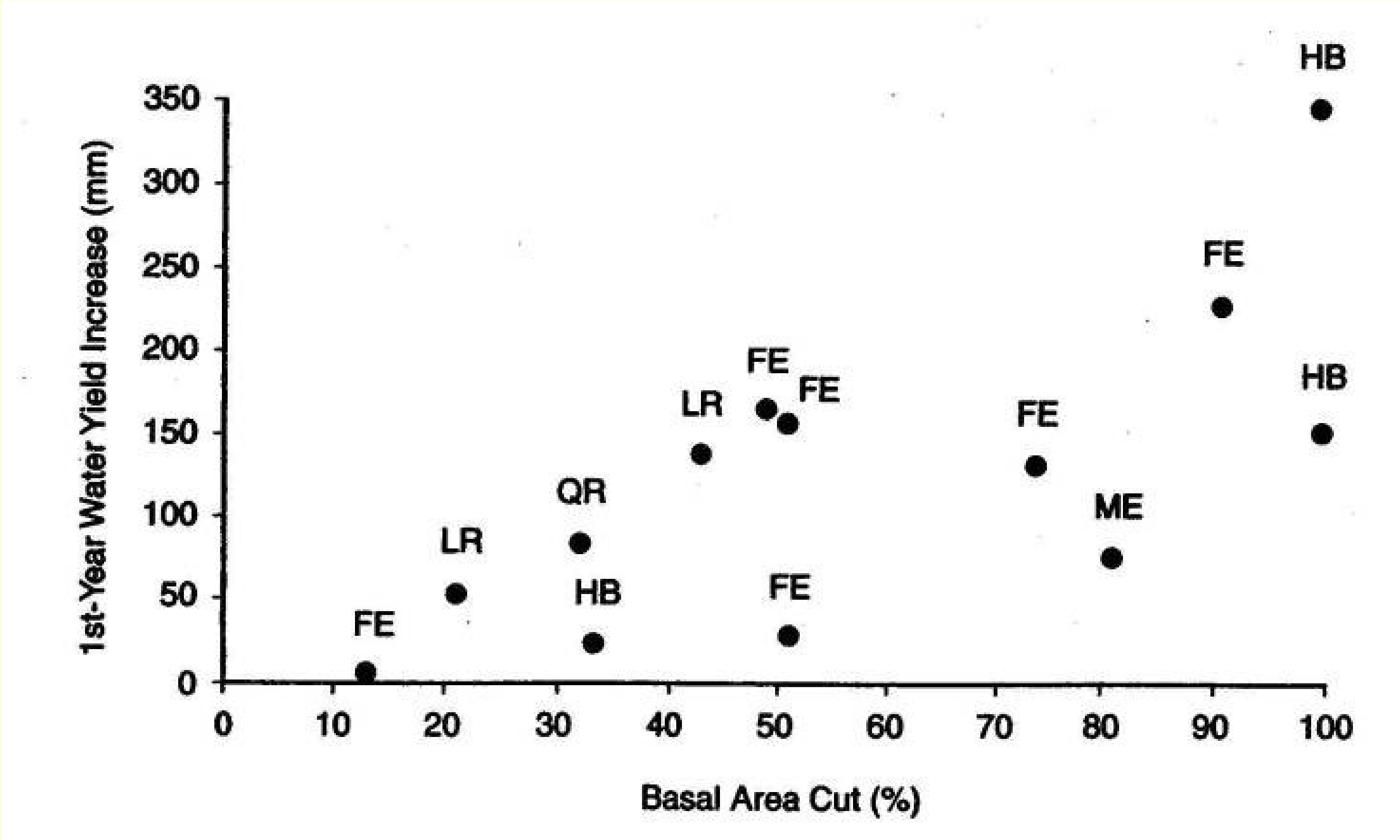


Recovery time for site to return to pre-harvest levels of calcium

Clearcut with biomass harvest:	160 years
Thinning with biomass harvest: (~ 50% removal)	70 years

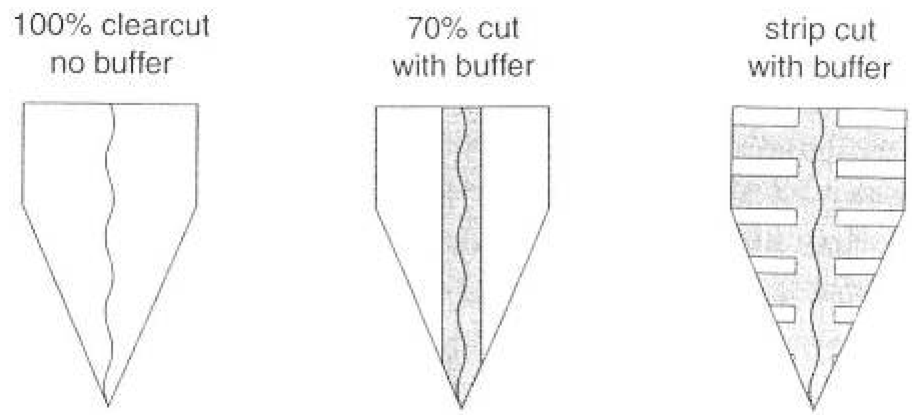
Consequences of heavy cutting on streamflow and water quality

- Increased water flow may increase nutrient loss and sedimentation
- Increased movement of harvesting equipment may cause soil compaction, leading to overland flow of water



Water yield (streamflow) increases in proportion to basal area cut in watershed

Nutrient losses in streamwater with three harvest methods



Nitrate:	18	9	4
Calcium:	4	3	2

(Units: mg/L)

Overland flow caused by soil compaction
on skid trail

Wildlife habitat conditions

- Clearcuts for early successional habitat conditions require biomass residue to be left on site
- Stands with thinned overstory canopies develop dense understory vegetation

Clearcuts to create good habitat are limited in size ….

… contain reserve trees …

… and slash

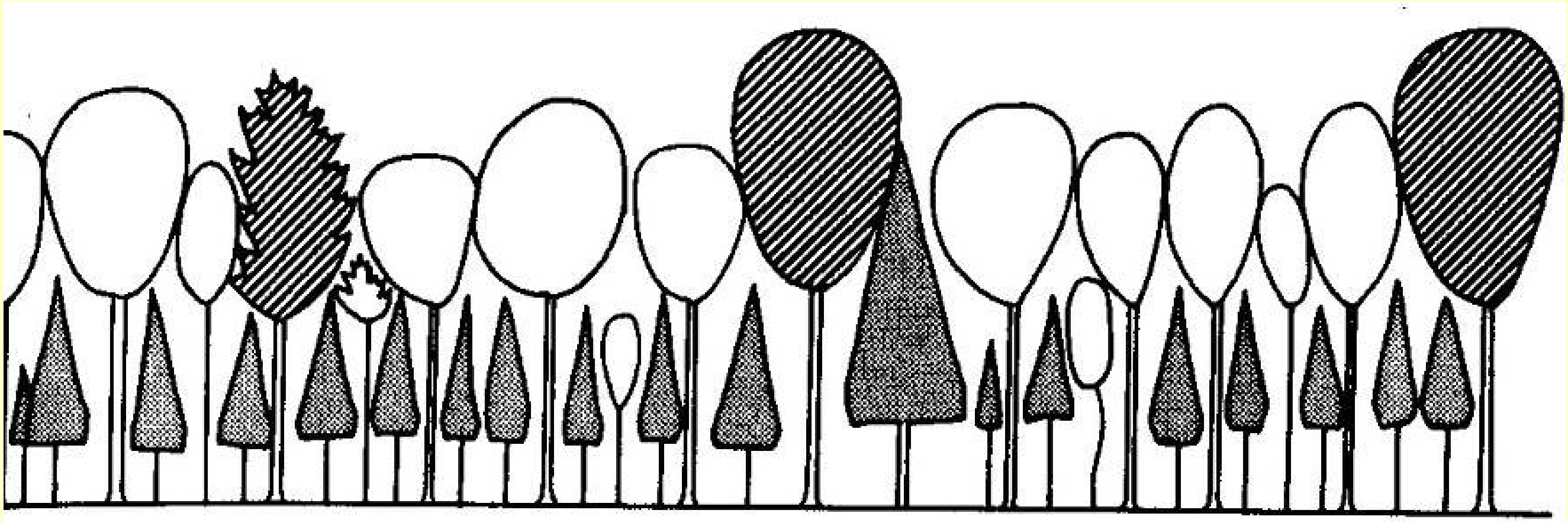
Thinned overstory (shelterwood) with dense understory provides conditions for more generalist species

Maintenance of high carbon sequestration rate

- Forest biomass crops can vary drastically in stand age and tree size at the time harvesting

Willow coppice system in Ireland.
Peak growth rate occurs at age 2 years;
harvest occurs at age 4 years.

Aspen stand peak growth occurred at ~10 years, and is being harvested at 20 years.



Stands with layered canopies are often the most productive:

- **the fast-growing upper layer creates a closed canopy quickly**
- **the slow-growing lower layer adds to the biomass production**

CONCLUSIONS

- Massachusetts forests can provide an annual biomass harvest of 500,000 to 900,000 dry tons/year.
- A typical sawtimber stand can provide a biomass harvest of 25 dry tons/acre/year in a partial harvest that also removes sawlog trees for lumber or veneer; this is a 1/3 removal of total biomass.
- Whole-tree clearcutting should not be used because of depletion of site nutrients.
- Stem-only harvesting should be the standard practice even in partial harvests for retention of site nutrients.

Whole-tree clearcut – New Hampshire – 1980s

- A combination of use of partial harvesting and adherence to Best Management Practices will avoid water quality problems from nutrient loss and sedimentation.

- Creation of early successional habitat for wildlife is not compatible with intensive removal of biomass fuels.

- Establishing and maintaining mixed-species stands on non-degraded sites will maintain high carbon storage rates into the future.